

THE PROCEEDINGS OF THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Series A. GENERAL ENTOMOLOGY

World List abbreviation: *Proc. R. ent. Soc. Lond.* (A)

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LONDON:

PUBLISHED BY THE SOCIETY AND

SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 12s. 0d.

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ON THE FORMATION OF SPECIES AND GENERA IN THE INSECT FAUNA OF THE LESSER ANTILLEAN ARCHIPELAGO

By R. G. FENNAH, M.A., F.R.E.S.

THE Lesser Antilles, if certain small islands lying off Venezuela are excluded, comprise all the islands which lie north of Trinidad ($10^{\circ} 40' \text{ N.}$) and south of the Virgin Islands ($18^{\circ} 28' \text{ N.}$). The islands lie spaced at more or less regular intervals on a submarine ridge some 500 miles long, which curves westward at its northern end to join the main east-to-west axis of the Greater Antilles.

Most of the islands are approximately oval in outline with a median ridge of high land running from north to south. This ridge varies in altitude from 1500 to 5000 feet. The coast area of each island has a dry scrub flora and the uplands a rain-forest: these two plant associations stand in marked contrast to one another and each may harbour its own endemic species of insects.

The affinities of an overwhelming part of the insect fauna of the Lesser Antilles lie with the tropical portion of Central America, and it is clearly from this area that immigration originally took place.

In Grenada, and to a lesser extent in St. Vincent, immigrant species from the Brazilian subregion, or their modified descendants, are to be found, but they are proportionately very few. It would seem that migration northward from Trinidad has been impeded by the double barrier of the Northern Range—a wall of mountains 2000–3500 ft. high which bounds the island on the north—and of nearly a hundred miles of sea beyond it.

Through this gap between Trinidad and Grenada the zoogeographer might draw a line of faunal division similar to "Wallace's Line" of the Malay Archipelago. Such a line, though by far the more important, is not the only one which may be drawn; a distinct break in faunal continuity also occurs between the island of Guadeloupe and the Leeward Islands which lie to the north of it. Here the stretch of intervening sea is abnormally large, being about fifty miles. The islands lying between these two lines, namely Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent and Grenada, have a more oceanic character than might be inferred from the existing literature on their fauna.

From the point of view of the student of evolution the Lesser Antillean fauna may be divided into four categories. The first includes recent immigrant species and native species of relatively high genetic stability; the second includes forms and varieties of widespread species; the third, a much smaller category, includes species occurring only in the Lesser Antilles; while the fourth includes only endemic genera.

Members of the first category exhibit merely trivial variation between individuals and need not concern us here. The forms and varieties in the second show slight but more stable differences than in the preceding, and these are appreciable only in the adult stage. Variation is found in the pigmentation of the integument, to a much lesser degree in the shape or length of unimportant dermal processes, and in habits. The pigmentation of the epidermis or its

setae may vary in three ways : firstly in the intensity or vividness with which a definite specific or generic pattern is developed, secondly in the replacement of the normal pigmentation by a definite alternative form, which usually intergrades with the original, and thirdly in a change of the pattern itself. Such variation is usually most pronounced on, if not actually confined to, the fore-wings in the Hemiptera and Coleoptera from which I have drawn most of my examples.

The first type of pigmentary change, that which concerns the vividness of the colour-pattern, appears as a variable character among individual specimens of the Scutellerine Pentatomid *Augocoris illustris* (Fabricius) and of several species of the Achilid genus *Catonia* Uhler (Fulgoroidea).

Rather more interesting, and confined no longer to individuals but to an upper montane district population, is the pigmentary variation shown by an undescribed species of *Acanalonia* Spinola (Fulgoroidea : ACANALONIIDAE). This insect lives in the mountain rain-forest of Dominica and is of a pure jade green at altitudes around 1000 ft., where it commonly feeds on *Simaruba amara* or *Clusia* sp. At altitudes above 2000 ft. its habitat is modified by the presence over all the woody vegetation of a dense coat of yellowish-green and brown fern-like moss; specimens taken in this formation are all yellowish-green sprinkled with brown. The distribution of this colour-form is coextensive with that of the mossy type of forest.

The second type of pigmentary change—the abrupt appearance of a pigmentation widely different from what might be considered the standard pattern is illustrated by a Flatid, *Petrusa marginata* Brunnich, which occurs in the Leeward Islands and in the Greater Antilles. This insect is usually dark in colour with a pure white submarginal band on the anterior part of the fore-wings. In the alternative form the whole insect is greenish-white, sometimes with a trace of orange around the apical margin of the fore-wings. (This pale form was described, and for long accepted, as a separate species, *P. pygmaea* (Fabricius).) In a long series of specimens a complete set of intergrades can be recognised. It should be added that this pale form does not represent a teneral adult of the dark form, nor is its appearance correlated with sex, time of year, or, as far as samples have indicated, with any constant proportion of the population.

The examples so far quoted are of insects which vary within a single island; an example of the first type of pigmentary change involving whole adult populations from different islands is provided by one of the CIXIIDAE, namely *Bothriocera eborea* Fennah, in which the fuscous pattern on the transparent fore-wings is dark in the St. Lucian strain and pale in that from St. Vincent. Similar modification is found on the lower side of the wings of certain Lycaenid butterflies, such as *Leptotes cassius* (Lucas).

Variation involving a change in pattern is seen in forms of the weevil *Diaprepes abbreviatus* L., in which the elytra are covered with ashy grey scale-like setae interrupted by smooth black longitudinal ridges. The length and number of the smooth denuded ridges vary constantly between the populations of different islands, and each arrangement is representative of its locality. In St. Lucia and in Puerto Rico (Greater Antilles) two or more forms may appear: in St. Lucia the two forms are linked by intergrades. The modification of the ridges is a morphological change, as the length of the smooth area depends on where the setiferous area is developed, and not on the colour of the setae themselves. In addition to this incipient morphological variation, a difference occurs in the colour of the setae: as already indicated, these are ashy grey, but in the

populations of two widely separated islands, Tortola in the British Virgin Islands and St. Vincent in the Windward Islands, they are bright yellow in colour.

Subspecific variation in the shape of unimportant epidermal processes is not easy to demonstrate, and the student must be thoroughly familiar with the degrees of specific variation in his group before he can evaluate with confidence trivial degrees of morphological difference. The Fulgoroidea sometimes show variation in the shape of processes of their complex male genital armature at subspecific level. For example, the phallobase of *Petrusa marginata* possesses a subvertical appendage on each side. This process when examined in a long series of specimens from within a single island is found to be either acuminate or broadly bifid at the upper end.

An example of inter-island variation along the same lines is provided by an undescribed species of the Flatid genus *Euhyoletta*. In this species a lateral process on each side of the phallobase is distinctly longer—though by very little—in specimens from St. Vincent than in others from Grenada. The subspecific nature of this variation is made evident by the well-defined differences which separate the Grenadan species from its nearest ally, *E. corticalis* Fennah in Trinidad. These examples will suffice to show that the earliest kind of morphological change can involve both shape and size.

The last type of subspecific variation, which can only be observed in the field, concerns the population habits. One of the most obvious of such modifications in habit is the preference shown by certain Lepidoptera for a single plant species out of a wide range of hosts as a site for oviposition. The principle which governs such selection on the part of the female is well known, but the limitation of a specific preference to the population of a definite area is not so widely recognised. An interesting phenomenon of this class occurs in the Lesser Antilles: in all islands the developing seed-pods of pigeon pea (*Cajanus indicus*) are subject to infestation by the moths *Etiellus rubedinellus* Zeller and less commonly *Ancylostoma stercorea* Zeller. In St. Lucia, and here only, there is added to these the Noctuid *Heliothis virescens* (Fabricius) as a major pest. *H. virescens* is present in all the other islands but confines its attentions to other hosts. To cite another example from a wider area, it may be mentioned that in Florida, U.S.A., the Southern Green Stink-Bug, *Nezara viridula* L., is a recognised pest of citrus. In the Lesser Antilles, in the course of five years' work on the pests of citrus, the author never encountered *Nezara viridula* breeding on any type of citrus or feeding on the fruit, while the total number of times that I have seen one of these insects resting on citrus must be less than a score, and this notwithstanding the fact that *Nezara* abounds in the West Indies.

Such are the subspecific variations detectable in the natural environment. Now we may briefly review the types of differentiation observed between endemic species. In the Lesser Antilles the specific level (though always arbitrary), in the orders of insects from which the examples are taken, may conveniently be established for the groups of most closely similar forms which are separated from one another by bridgeless gaps in morphological characters and which show evidence of being reproductively isolated.

Endemic species may contrast with each other markedly in pigmentation, the contrast involving in the Issid genus *Colpoptera* Burmeister even colour-pattern of the eyes: it is usually in the fore-wings that such differences are best displayed, as illustrated by the weevil genus *Cholus* Germar or the *hemigrammus* group of *Diaprepes* Schoenherr. Differences in size begin to

become appreciable: *Cholus spinipes* Fabricius from Grenada is larger than *C. adspersus* Fahringer from St. Vincent or *C. zonatus* Swederus from St. Lucia. Morphological differences in genital structure are almost universal in most orders of the Pterygota, and in the Homoptera Fulgoroidea include the shape of the anal segment of the male, of the non-muscled processes of the ninth abdominal segment as well as of the phallus and harpagones, and in the female the shape of the sclerites in the wall of the vagina, the shape of the spermatheca and the armature of the bursa copulatrix. In some groups the shape of the vertex shows plasticity at specific level, as in the Achilid genus *Catonia* Uhler or the Tropiciduchid *Remosa* Distant, while the shape of the fore-wings may vary markedly, as in the Flatid genera *Cyarta* Stål and *Euhyloptera* Fennah, and in many of the subfamily FLATOIDINAE.

Differences in behaviour, possibly correlated with habitat, are occasionally discernible: for example, the coast-dwelling Flatid *Antillormenis contaminata* Uhler is not particularly agile at any time, and during the day shelters low on the plant or even among leaves on the ground, while the closely-allied *A. sancti-vincenti* Fennah, which lives in the mountain forest, is in evidence throughout the day and is relatively agile and wary. [The most striking differences in habits between species are perhaps to be found in the Hymenoptera, notably in the genus *Trypoxylon* Latreille, but such examples do not fall within the range of Lesser Antillean endemic species as far as the author is at present aware.]

Differences occur in the pigmentation of the nymphs of some Hemiptera: these are of no great magnitude or reliability, and otherwise the nymphs remain very uniform in gross structure. In holometabolous groups larval distinctions are often found possible though on characters both slight and few. Rather unexpectedly a series of pronounced and bizarre morphological differences have been found to occur in the egg stage between species of the genera *Dioxyomus* Fennah and *Neotangia* Melichar in the Tropiciduchid Fulgoroidea. Such differences, which involve the operculum and its process, are apparently not widespread in the Fulgoroidea or elsewhere, though the subject requires study.

Between endemic genera the differences are so pronounced and so divergent in kind in different families or orders as to offer little clue to their relationship through common ancestry. All the characters which have been listed before are included in these differences—pigmentation, size, shape of vertex, fore-wings and genitalia, and habits—and are reinforced with further differences, such as occur in general bodily proportions, fore- and hind-wing venation. Moreover at this stage differences may develop in internal structure; for example, in the New World subgenus *Melanoliarius* Fennah of *Oliarus* Stål in the CIXIIDAE the number of follicles in each testis is six in all species so far examined: in the superficially very closely allied genus *Vincentia* Uhler, on the other hand, there are eighteen to twenty follicles in each testis. It is at the generic level that sexual dimorphism begins to appear in some groups, such as the Cenchreine DERBIDAE, where genera such as *Patara* Westwood show sexual dimorphism while others do not. Differences in habit are found between genera: in the family KINNARIDAE (Fulgoroidea) members of the genus *Prosotropis* Uhler almost invariably feed and rest with the wings held upward and diverging, but species of its nearest ally, *Quilessa* Fennah, continually carry the wings folded against the abdomen.

Nymphal differences between genera become fairly well marked in hemimetabolous insects, while in holometabola larval differences often are very

pronounced, especially in some groups of widespread Lepidoptera, such as the SPHINGIDAE.

What is believed to be an example of the recent formation of genera is provided by the Tropiciduchid genera *Cyphoceratops* Uhler, *Parahydriena* Muir and *Chasmacephala* Fennah. These are all isolated from other genera of the family by the compressed form of the pronotum, and from each other by bizarre differences in the shape of the vertex. The genus *Chasmacephala* contains species distributed throughout the Windward Islands, and well separated by conventional differences in the male genitalia; *Cyphoceratops* occurs in Cuba and Haiti, and *Parahydriena* in Santo Domingo and Puerto Rico. The number of characters which these have in common would seem to indicate that in spite of their different head-formation they have diverged at no distant period from an isolated ancestral form, and have scarcely passed the stage of being subgenera.

Such are the differences at various group-levels in the Lesser Antillean insect fauna. Now let us consider the way in which they may have arisen.

Three sets of factors appear to be involved in the evolution of an endemic species: factors stimulating variation, factors governing the direction of variation and lastly factors controlling the fixation of the variants.

The nature of the factors which stimulate the organism to vary is a matter of speculation. The author suggests that fundamentally only one is operative and this is simple irritation of protoplasm, brought about, perhaps, by fluctuations in the micro-environment affecting the metabolism of the individual throughout its development. Heat, cold, low or high humidity, varying diet and the need for movement all affect the glandular and muscular activity of the insect. Muscular activity, coupled with activity of the spiracles, will influence the degree of oxygenation of the tissues. It would seem by no means impossible that fluctuation in the oxygen content of the tracheolar fluid which bathes and supplies the germ plasm throughout its differentiation has a sufficiently irritating effect to cause occasional abnormality at the reduction division of the ovogenic and spermatogenic cells.

If this possibility be admitted for the fluctuations of gases dissolved in the body fluid it must also be admitted for fluctuations, both quantitative and qualitative, of compounds in solution—compounds resulting from the metabolism of different kinds of plant or animal food.

The effect of variation in food on the development of certain phytophagous insects is known to be considerable, though evidence of any effect on the germinal tissues is wanting. The presence of metallic salts in the larval food leads to the appearance of melanic forms of the adult in some Macrolepidoptera. Moreover, the author has obtained a black form of the Green Stink-bug, *Nezara viridula* L., by rearing a brood on diet similarly treated. It may be added that a black form of this bug has been recorded in the field in Florida, and it would seem not unreasonable to ascribe its appearance to a nutritional cause.

(If it is permissible to digress for a moment, the author would like to emphasise that the food of many insects, especially in the Hemiptera and Thysanoptera, should be defined not in conventional terms of host *plants* but of host *cell-solutes*. Many Homoptera feed on a variety of plants, often botanically unrelated, but only thrive vigorously when their hosts are in a certain physiological state (usually with a high C/N ratio). The mealy-bug *Puto barberi* Cockerell, which attacks citrus in the West Indies, cannot be reared or even kept alive on young, fresh foliage or twigs, but grows and multiplies readily when provided with twigs that are in an unthrifty condition, notwithstanding the fact that both

sets of twigs may be growing on the same individual plant. Furthermore, it has been shown by Squire that the long diapause of the Pink Boll-worm of cotton in the West Indies (*Pectinophora gossypiella* Saunders) occurs only after the larva has fed exclusively on dry food. When it feeds on normally moist food it pupates after a very transient diapause.)

As to the factors which govern the direction of variation, it can only be stated that in each group of insects there seems to be a more or less definite order of instability in the arrangement of the genes and that displacements of groups of genes tend to occur in a parallel manner in allied species, producing the parallel variation which is so common. The order of instability may be determined by the arrangement of the genes on the chromosome: certain groups of genes, occupying the same relative position on a similar chromosome in allied insects, may be exposed, by the accident of their position, to a greater hazard of displacement during an abnormal mitosis than other groups. While parallel variation is usual (as, for instance, in the subequal changes in genitalia in each of a compact group of species), occasionally a character is observed to vary at a genealogically earlier stage in one species than in others, as if the genic displacements and rearrangements had not conformed to the standard sequence. The result, in a well-known genus, is a perfectly recognisable species set apart by reason of variation in what is regarded by the taxonomist as a single generic character. In the Cixiid Fulgoroidea *Pintalia discrepans* Muir is perhaps an example of this kind of genetically precocious change.

Fixation of variations when they have occurred is, on present evidence, overwhelmingly a function of isolation of the variants. Topographical isolation at once suggests itself—oceanic islands, plant associations and the like, because the distribution of the variants is coextensive with the area which they occupy. But the author would suggest that isolation of variants begins at a much lower level than that of the district community, and that possibly the earliest type of isolation is physiological, and originating in a preference which becomes habitual, and that the fixation of the habit leads to reproductive isolation. In an examination of the male genitalia of comparatively long series of specimens of endemic species each confined to a single island, the author has repeatedly been impressed by the homogeneity of the sample as far as the organs under scrutiny were concerned. In each endemic species of Fulgoroidea nothing indicative of a range of subliminal morphological variations has yet been noted, nor has any abnormal, freak or mutant specimen been discovered. Yet if the island, or plant association, is the initially operative isolating agent, as it might appear to be from the distribution of each endemic species, more variation within the population inhabiting such areas is to be expected than has been found. It must be borne in mind that, in some groups of insects at least, morphological change leading to species-formation begins in organs which from their position are not subject to any test of efficiency in a hostile external environment. As far as the Fulgoroidea are concerned, the author is forced by the weight of evidence to believe that the variations in phallic and periphallallic armature found in Lesser Antillean endemic species raise no mechanical barrier to copulation between the male of any one species and the female of an allied species; furthermore in view of the almost unchanging nature of the female organs in some of these species it is difficult to imagine how any slight modification in the male armature can be of immediate advantage to its possessor, as the modified element has no critical function to discharge.

It was found that when specimens of both sexes of the two endemic species *Antillormenis contaminata* Uhler and *A. sancti-vincenti* Fennah, which

inhabit respectively the coast scrub and the mountain forest in St. Vincent, were placed together in a cage after being reared from the last instar the male of one species ignored the female of the other but mated with the female of his own species. This finding has not yet been confirmed by repetitions of the test, so that no final conclusions can be drawn, but the first result does legitimately suggest the possibility that reproductive isolation may be brought about at an early stage in variation by sexual selection on the basis of an imponderable factor of a physiological nature.

The outstanding problem, at least in the study of endemic Fulgoroidea, is to account for the lack of subliminal or minor variation within the isolated species in morphological characters which are strikingly different between species. The above hypothesis carries with it the implication that the imponderable factor which limits the extent of mating or otherwise governs selection is linked or highly associated with a capacity to influence the morphological development of the offspring of the opposite sex in a definite and precise direction, as it is evident from observation that in some families both sexes vary together from their counterparts in other islands, and in both sexes the morphological changes are equally uniform in samples of any one population. This generalisation may be best understood from a hypothetical example. Let it be supposed that a female variant with the biological habits of a Fulgoroid becomes sexually mature after reaching the adult form more rapidly than the remainder of the population. She lays eggs sooner and accordingly spends less time exposed to predators before oviposition than do her companions. Moreover, in a seasonal rise in population the early-laid eggs are less liable to destruction by egg-parasites, as the parasite population has not built itself up. If the character is inheritable, and the males prefer the females of their own strain, a quick-maturing form will replace the normal form in relatively few generations (and incidentally set in motion the natural selection of a more early-attacking strain of parasite). If it be further assumed that the physiological or genetical change which expressed itself in early maturity of the original female also incidentally affected the mechanism governing the reduction division of the egg so that in the males of the offspring, when they reached the last instar, "growth organisers" at certain unstable growth centres were more than usually stimulated, then elongation (by more prolonged cell division) and stronger curvature (by prolonged cell division and growth on one side more than another) of processes on the male genitalia could be produced almost in one step. In this hypothetical case the processes on the male genitalia could all be changed in shape in the same way in each individual (giving the uniformity actually found in the field) and yet their shape would be merely the incidental by-product of competitive evolution in the female of the species, and of no immediate biological significance (as seems actually to be so in many male Fulgoroidea).

The only alternatives to such a view seem to be either that these uniform populations diverge at an equal rate from their common ancestor through some orthogenetic influence, or, what is even less acceptable, that all the present island species, normally exhibiting a wide range of variation between individuals, happen to have reached a temporary (and simultaneous) stability, with the most successful strain in complete possession of the habitat. Compared with the last two, the first hypothesis imposes the least strain on the investigator's credulity.

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A LONG-RANGE MIGRATION OF THE DESERT LOCUST FROM SOUTHERN MOROCCO TO PORTUGAL, WITH AN ANALYSIS OF CONCURRENT WEATHER CONDITIONS

By Z. WALOFF, M.Sc.

(*Anti-Locust Research Centre.*)

ACCORDING to the information kindly collected and supplied to the Anti-Locust Research Centre by Dr. A. J. Duarte of Estação Agronomica Nacional, Sacavem, large groups, and in some cases considerable swarms, of the Desert Locust (*Schistocerca gregaria* Forskål) were seen on 12th October, 1945, in 22 different localities of western Portugal, from Lisbon to the northern boundary. About the same time, some locusts were observed farther north, at Vigo in Spain. The swarms mostly consisted of sexually immature (red) locusts, but those seen at Lisbon and Oporto contained an admixture of mature (yellow) individuals.

As a rule, swarms of the Desert Locust produced in late summer in western French West Africa migrate in the autumn across Mauritania and Rio de Oro northwards towards Morocco. In 1945, young swarms, which appeared in September in southern Mauritania, reached south-western Morocco early in October. On the 9th a large red swarm, with an admixture of mature yellow individuals, was reported near Tiznit, 10 miles from the Atlantic coast, on the southern borders of the Sous Valley. At that time the rest of Morocco and Algeria were completely free of swarms, so that south-western Morocco was the nearest area to the Iberian Peninsula where locusts were present.

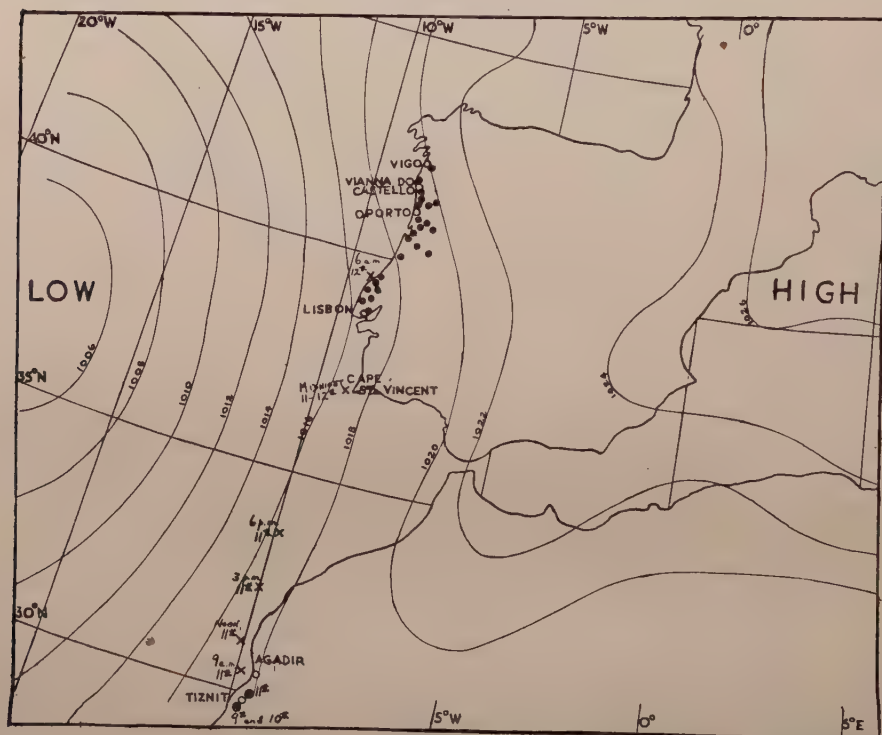
Had the locusts which appeared in Portugal on the 12th October arrived there overland, they would almost certainly have been reported doing so by the French locust information service in Morocco. As no such migration was observed, it appears probable that they flew over the sea, and thus traversed at least 612 miles (the distance between a point at sea off Tiznit and Lisbon) without settling down. No information is available on the times of the day at which locusts appeared in different localities in Portugal, but their distribution on the day of appearance (see Map) and the fact that on that day all the recorded directions of their flight over Portugal were southwards, suggest that some of the swarms travelled over the sea as far north as the latitude of Viana do Castelo and, possibly, Vigo, *i.e.* more than 800 miles from Tiznit.

Normally, swarms of the Desert Locust settle down for the night, and distances traversed by them during the day are of the order of 20–30 miles (Dr. D. L. Gunn, unpublished). It was thought, therefore, that the investigation of the weather conditions at the probable time of flight to Portugal might yield some information on the meteorological factors under which such an exceptionally long continuous flight took place. With this end in view, permission was obtained from the Director, Meteorological Office, to examine the relevant synoptic charts and to consult the staff at the Central Forecasting Station, M.O., Dunstable. I take this opportunity to express my gratitude to the Director of the Meteorological Office for his permission, and to the members of the forecasting staff at Dunstable, for the interest they have taken in this matter, and for all the help and information which they gave me.

Locusts were again reported circling near Tiznit on the 10th, and slightly

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farther north, near the coast in the Sous Valley, on the 11th. The temperatures recorded on the 10th at the nearest meteorological station (Agadir, on the Atlantic shore in the north of the Sous Valley) were moderate, namely 63° F. (17.2° C.) at 9 a.m., 73° F. (22.8° C.) at noon and 81° F. (26.7° C.) at 3 p.m., and the air was calm in the morning, with light on-shore winds by day. Gunn *et al.* (1945) has found that swarms of the Desert Locust take to flight at air temperatures between 19° and 23° C., so that on the 10th October conditions favouring active flying obtained only during the middle of the day.



Large dots—positions of locusts in S. Morocco on the dates indicated. Small dots—positions of locusts in Portugal on the 12th October, 1945. Crosses—successive positions, at the hour and date indicated, of an air mass at 1500–2000 ft. Isobars on the 11th October, 1945; pressure in millibars. The last two items reproduced by the kind permission of the Director, Meteorological Office.

On the 11th October, however, the temperatures at Agadir rose sharply from 68° F. (20° C.) at 6 a.m., to 95° F. (35° C.) by noon; it is probable that 80° F. (26.6° C.) was reached already by 8 a.m. At the same time a strong (20–30 m.p.h.) and gusty easterly wind blew over the Sous Valley in the morning and the forenoon. This wind, however, did not persist for many miles beyond the shore, but over the sea gave way to a strong southerly current, probably extending to a height of over 5000 ft., which on the 11th and the following night blew over the eastern Atlantic between a depression situated to the west of Portugal and an anticyclone over the Mediterranean (see Map).

Neither the time of departure of locusts from south-western Morocco, nor the hours of their arrival at Portugal are known. Since the locusts were able to fly by day on the 10th, it was possible for some of them to fly out to sea, and

to start on their northward flight, on that date. However, the weather conditions would not in themselves favour or induce the seaward flight, and if it took place, the locusts would have to remain on wing for two consecutive nights to reach Portugal on the 12th. It appears much more probable that the migration started on the 11th. On that day the sharp rise of temperature would cause the locusts to be active and air-borne early in the morning, and they would be liable to be blown, by the strong easterly wind, out to sea, and become involved there in the powerful southerly current which would carry them northwards. If one assumes that the locusts started their northward journey over the sea at about 9 a.m. on the 11th, and arrived at Portugal about 9 a.m. on the 12th, those appearing at Lisbon would have to travel at the average rate of 25.5 m.p.h.; to arrive at noon, their average speed would have to be 22.6 m.p.h. The surface winds over the Atlantic during the 11th were in general below that speed, reaching the strength of 20–25 m.p.h. over parts of the traverse only; moreover, off the coasts of Portugal they decreased in strength during the night of the 11–12th and on the following day. Therefore, the locusts could not have been transported from south-western Morocco to Portugal between the 11th and the 12th October by the surface winds. At the height of 1500–2000 ft., however, the winds were very much stronger, averaging about 30 miles per hour, so that at that level, an air mass which was off Agadir at 9 a.m. on the 11th would reach Cape St. Vincent by midnight, and would be to the north of Lisbon by 6 a.m. on the 12th (see Map). The exceptionally sharp rise in temperature over the Sous Valley in the morning of the 11th suggests that convectional currents were set up over that area. Should the locusts have been carried up by a convectional current to an altitude of 1500–2000 ft., before being blown out to sea, at that level the southerly current would transport them to Portugal by the next morning. At the ground temperature of 80° F. at Agadir, the temperature of ascending air must have been about 70° F. (21° C.) at 2000 ft., *i.e.* it remained at the level at which active flight is possible. No records are available for the temperatures at 2000 ft. over the sea, or over Portugal, for the night of 11–12th, but at 3 p.m. on the 11th over Lisbon the temperature at that level was 70° F. This suggests that, at least by day, the temperatures at 2000 ft. remained sufficiently high for flight all along the traverse.

The locusts were probably enabled to settle over Portugal by the decrease in the strength of wind, both at 2000 ft. and at surface level, over the coastal and inland districts in the night of 11–12th, and during the following day.

PREVIOUS RECORDS OF LONG-RANGE MIGRATIONS OVER THE EASTERN ATLANTIC.

Several records of Desert Locusts being observed over the Atlantic are in existence. In September, when swarms generally are still in Senegal and Mauritania, some may arrive at Cape Verde islands (Chopard, 1936). On 13th September 1839 the brig "Levant of Boston" at 18° N. and 450 miles off the coast of Mauritania encountered a severe gale and was surrounded for the next two days by large swarms of locusts (Anonymous, 1841).

In October 1869 numerous Desert Locusts were seen in Cornwall, and from there spread northwards to the Midlands and to south-eastern Ireland. Brown (1870–71), who recorded this invasion, suggested that the individuals which had reached the British Isles were the remains of a large swarm, which having set out from north-western Africa was caught by a south-easterly wind and carried out to sea.

On 7th October, 1916, numerous specimens of the Desert Locust "in a lively condition" came aboard the bark "Robert Crafton" while the vessel was at lat. $20^{\circ} 57' N.$, long $39^{\circ} 28' W.$, 1200 miles from the African coast (Howard, 1917).

In November, 1844, a large swarm at least 5-6 miles in diameter visited Madeira, and after 2-3 days disappeared over the sea (Darwin, 1872).

On 21st November, 1811, s.s. "Georgia," when sailing 200 miles off Canary Islands, encountered a swarm of locusts; "a light wind sprang from N.E., with which there fell from the cloud an innumerable quantity of large grasshoppers" (Kirby & Spence, 1856). On 2nd November, 1865, several specimens of *Schistocerca* were taken on board the s.s. "Harrisburg" at lat. $25^{\circ} 28' N.$, long. $41^{\circ} 33' W.$, 1200 miles from land; the locusts arrived during a rainstorm (Selys-Longchamps, 1878). In November 1932 several specimens of *Schistocerca*, apparently all belonging to the same swarm, were captured on the island of San Miguel, Azores. The swarm was believed to have come from Morocco, for its passage was observed at Madeira, and the wind was blowing from east and south-east during that period (Vayssi re, 1933).

The above records suggest that during the autumn season, when swarms of *Schistocerca* are migrating northwards near the Atlantic seaboard, they not infrequently fly out to sea, and may be carried for immense distances by suitable winds. The 1945 migration, therefore, was not exceptional, but provides the first case in which the points of departure and arrival of a swarm are known, and the weather conditions that made possible the continuous flight for some 800 miles are available for analysis.

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IMPREGNATING POLYVINYL ALCOHOL WITH PICRIC ACID FOR THE SIMULTANEOUS STAINING AND PERMANENT MOUNTING OF ACARINA

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In the study of mites entomologists and acarologists have for a long time used media based upon a mixture of gum arabic and chloral hydrate, but the widely used "Berlese's Fluid" based upon this mixture soon shows signs of crystallisation.

Modifications of the formula by Swan (1936, *Bull. ent. Res.* **27** : 389-91) and Womersley (1943, *Trans. roy. Soc. S. Aust.* **67** : 181-2) to obviate this disability have not met with the desired success. Moreover, many workers have found that minute details of specimens are not visible in gum-chloral mountants.

In the early part of 1944, while attached to the Medical Department of the Royal Navy, I obtained some polyvinyl through the courtesy of the London School of Hygiene and Tropical Medicine, when it was first being used there for preparations of mosquito larvae.

Since that time I have experimented with media composed of varying proportions of polyvinyl alcohol and lactophenol impregnated with picric acid. The object was to produce a medium which would include, in one complete stage, the processes of killing, fixing, clearing, extension and staining of the specimen when mounted straight from life.

The limitations apparent in gum-chloral media do not occur when using this medium. Moreover, it is reliable and successful in both tropical and temperate climates for the permanent mounting of Acarina and small Arthropoda.

The impregnation of the medium with picric acid produces a preparation in which the more delicately chitinated forms are well stained and distinctive. This distinctiveness is gradually heightened after first mounting because the specimens tend to become more stained as the surrounding medium loses colour. Even the fine hairs take up the stain and minute serrations on the hairs themselves are clearly defined.

PREPARATION OF THE PERMANENT MOUNTANT.

Solution. 6.3 gm. polyvinyl alcohol, 18 c.c. absolute alcohol saturated with picric acid, 35 c.c. distilled water, 45 c.c. lactophenol.

Method.

1. 6.3 gm. of the polyvinyl alcohol are transferred to a clean dry beaker flask (approx. 250 c.c. capacity).
2. Add 18 c.c. of absolute alcohol which is first saturated with picric acid.
3. Stir thoroughly with a glass rod to form a homogeneous paste.
4. Add 35 c.c. of distilled water.
5. Stir thoroughly to a gelatinous consistency.
6. Add 45 c.c. of lactophenol.
7. Heat the solution in a water-bath until it clears and then leave to cool.

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The rapid and easy preparation of the medium is a distinct advantage over that of gum-chloral media, which are not a little tedious to prepare.

It is advisable when storing the solution not to expose it to light.

PREPARATION OF TEMPORARY MOUNTANT.

Solution. 6.3 gm. polyvinyl alcohol, 36 c.c. absolute alcohol (with or without picric acid), 75 c.c. distilled water.

Method.

The same procedure as for the preparation of the permanent mountant except that the solution is heated in a water-bath after the addition of the distilled water. When clear, it is allowed to cool and is then ready for use. Should the mountant become too viscous over a period of time, this is rectified by warming the solution after adding a little water and alcohol (2 : 1 mixture).

MOUNTING TECHNIQUE.

For both temporary and permanent preparations specimens can be mounted straight from life, water, lactic acid or alcohol.

A fine brush is used to transfer live specimens to a dry clean slide. Should mites be taken from flour or any fine particled food product and placed on the slide, it is preferable to allow the mites to separate themselves from the food particles, which are then brushed away. The mites are then grouped together with a clean brush and covered with a drop of the mountant. If taken from a preserving liquid the mites are pipetted on to the slide and then covered.

Should air droplets appear adhering to a specimen, take a fine needle and move the specimen to the surface of the medium and allow the air droplets to escape.

The coverslip is placed in position while the mites are still active. The slight pressure of the coverslip upon the specimens results in their retaining an extended position.

For identification, drawing or measuring, mount in the temporary mountant with or without the picric acid stain, according to the delicacy of the specimen.

Although the temporary mountant is practically semi-permanent, specimens required for reference collections are permanently mounted and stained. The permanent preparation hardens in 48 hours, and the specimens are distinctively stained in 24 hours.

Gentle heating in an oven or over a spirit lamp, just after mounting, results in perfect extension and clearing and quickens the killing time and staining process.

SUMMARY.

1. A medium impregnated with picric acid for the simultaneous staining and permanent mounting of delicately chitinised Acarina is described.
2. The limitations apparent to workers using gum-chloral media do not occur in this medium; hence it is more favourable than "Berlese's Fluid."
3. The rapid and easy preparation of the medium is a distinct advantage.

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SOME EFFECTS OF ATMOSPHERIC HUMIDITY ON TWO NYMPHALIDAE: *AGLAIS URTICAE* L. AND *ARASCHNIA LEVANA* L.

By Jean LECLERCQ, F.R.E.S.

(Belgian Fellow of the British Council.)

I HAD the opportunity in June 1943 of breeding a number of caterpillars of *Aglais urticae* L. and of *Araschnia levana* L. (from eggs of the first generation) and I thought it would be interesting to test the effects of humidity on their pupae, for little is known about the humidity relations of any NYMPHALIDAE.

Caterpillars were bred on nettle, and experiments were carried out in a room at the outdoor shade temperature. Immediately after pupation, pupae were put in glass tubes, hermetically closed, with constant relative humidity controlled by means of supersaturated salts (Buxton, 1931; Zwölfer, 1932, and others).

RESULTS.

(1) *Aglais urticae* L.

Pupae of this species were found to be very little influenced by atmospheric humidity. Butterflies hatched under all conditions from 7% R.H. to 100% R.H., and no significant mortality was recorded at any percentage. The time for hatching was also eight to nine days under all conditions without any indication of lengthening in moisture or dryness.

However, butterflies obtained in saturated air often remained unable to extend their wings completely. On the other hand, some specimens bred in dry air could not escape completely from their pupae and died in a position of half emergence.

(2) *Araschnia levana* L.

A preliminary note has already been published giving some of my results for this species (Leclercq, 1946). It was shown that its pupae are also resistant to all conditions of humidity, but less resistant than *Aglais urticae*. Many pupae died at 100% and under 40% R.H.

The duration of development is also affected by atmospheric humidity. Butterflies appeared as follows :—

At 100% R.H., after an average of 12·4 days.

At 85 to 79% R.H., after an average of 13·3 days.

At 55% R.H., after an average of 13·5 days.

At 45 to 35% R.H., after an average of 13·6 days.

At 20 to 0% R.H., after an average of 14·7 days.

As with *Aglais urticae*, it was shown that many butterflies hatched in moist air were never able to extend their wings normally.

An interesting effect of humidity on coloration was recorded for this species, which is well known for its seasonal dimorphism. My pupae were expected to produce butterflies of the form *prorsa* L. darker than the summer form. In fact all the specimens obtained between 79% and 45% R.H. were normal *prorsa* L. But specimens obtained by breeding in very moist air show a tendency to be

darker, the majority of them belonging without doubt to the aberration *obscura* Frühstorfer.

Moreover, butterflies from very dry conditions were much brighter, some of them closely resembling the aberration *intermedia* Stichel.

There is, therefore, definite evidence that humidity can be of importance in the determination of the seasonal dimorphism in this species. Similar results were previously obtained using heat or cold (chiefly Söffert, 1924) and melanistic forms of some Lepidoptera were produced by the influence of humidity on caterpillars (Pictet, 1904, 1905). These experiments, proving definitely that the coloration of butterflies may be affected by atmospheric humidity acting on the pupal stage only, seem to me to be of some original interest.

ACKNOWLEDGMENTS.

My experiments were carried out in the Laboratoire de Physiologie Animale of the University of Liège (Belgium). I wish to thank Prof. Z. M. Bacq for constant help and invaluable advice. My thanks are also due to M. J. Hackray (Verviers) for comment about the colour forms of *Araschnia*.

This paper was written whilst holding a grant of the British Council to study at the London School of Hygiene and Tropical Medicine. I am indebted to Dr. K. Mellanby for suggestions and help in the writing of my manuscript.

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EGG-BURSTERS IN SOME MORE FAMILIES OF POLYPHAGOUS BEETLES AND SOME GENERAL REMARKS ON EGG-BURSTERS

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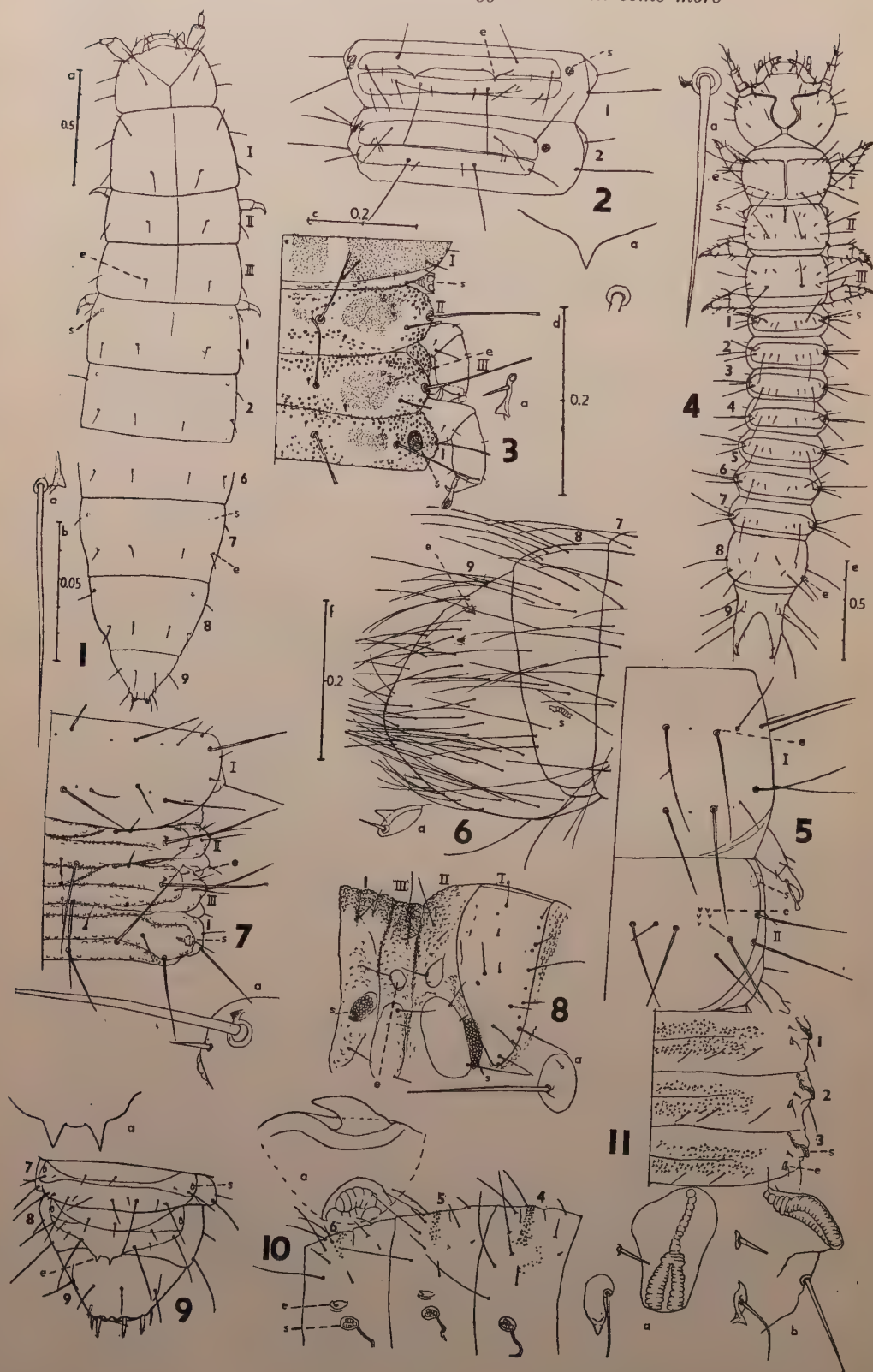
HATCHING-SPINES or egg-bursters have so far been known in the suborder Polyphaga of the Coleoptera only in Haplogastra, Phytophaga, Rhynchophora and COCCINELLIDAE, in addition to those of a different type found in SILPHIDAE and perhaps LAMPYRIDAE. The discovery of egg-bursters, to be described in this paper, in six more families of Polyphaga, modifies therefore in a somewhat unexpected way our present knowledge of the distribution of these organs. In the present communication the egg-bursters of HISTERIDAE, NITIDULIDAE, TENEBRIONIDAE, PYROCHROIDAE, MELANDRYIDAE and PTINIDAE, *i.e.* of families belonging to Hydrophiloidea, Clavicornia, Heteromera, and Terebrilia, are described and some notes concerning the distribution of egg-bursters in beetles and insects generally appended.

The egg-bursters of HISTERIDAE, as observed in first-stage larvae of *Carcinops quatuordecimstriata* Stephens, consist of a strong, backwardly directed spine on either side of the first abdominal tergite (fig. 2). They are situated on the praetergum somewhat nearer to the median line than to the spiracle, and consist of a simple spine on a broad sclerotised transverse base, without any setae or hairs.

The lateral part of the meso- and metanotum in *Meligethes* Stephens (as seen in *memnonius* Erichson and *umbrosus* auct., non Sturm?) is provided with a strongly sclerotised tooth, preceded by a short seta (fig. 3). These egg-bursters are situated in front of the second strong seta from the median line, a seta which is, however, considerably shorter than the first and third setae.

In TENEBRIONIDAE egg-bursters are present on two or three thoracic segments and the first eight abdominal segments as a minute tooth-like spine at the base of a strong seta near hind margin (fig. 1). These spines are of equal size or even somewhat stronger anteriorly in *Tribolium confusum* Jacquelin du Val, but in *Tenebrio* L. and especially in *Helops quisquilius* Sturm there seems to be a distinct tendency for them to become slightly larger behind, and particularly on the eighth segment. In *Tenebrio molitor* L. the egg-bursters are present at a paramedian seta on hind margin of each thoracic and the first abdominal segment and at a strong seta near the hind angle of the second to eighth abdominal segments; in *Helops quisquilius* Sturm, at the same places but not on the pronotum; in *Tribolium confusum* the egg-bursters lie at the base of the second seta from the middle in the posterior row of each segment from at least the second to the eighth abdominal one (the only available larva is incomplete, the thorax and first abdominal segment being lost). Although these egg-bursters of the TENEBRIONIDAE are very small, it is nevertheless remarkable that they have apparently never been seen before in *Tenebrio*, the larva of which has so often been studied. There is, however, a note by Kolobova (1927) describing similar spines in the same position in soil-inhabiting Tenebrionid larvae. Although Kolobova has not commented on the function and significance of these spines, there can be no doubt that she is referring to the egg-bursters.

The same condition of the egg-bursters as in TENEBRIONIDAE is found in the
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PYROCHROIDAE (*Pyrochroa coccinea* L. and *serraticornis* Scopoli), the spines (fig. 4) being situated at the base of the paramedian seta at the hind margin of each thoracic segment and at the base of the strong seta just inside the hind angles of the first eight abdominal segments. Very similarly in *Abdera flexuosa* Paykull (MELANDRYIDAE) a minute spine at the base of a seta is present on the anterior eight abdominal segments and on the meso- and metathorax, the seta being of moderate length and on the abdominal segments the second above the spiracle. In *Osphya bipunctata* F. (fig. 5) a pair of egg-bursters are present at the second strong seta from the middle of both transverse rows of the pronotum and a group of 5-6 sharp spines on antero-lateral part of mesonotum level with the pronotal egg-bursters, but there are no egg-bursters on the other segments.

First-stage larvae of *Niptus hololeucus* Faldermann (PTINIDAE) do not show any spines on the thoracic and first eight abdominal segments, but the ninth abdominal segment carries a pair of tooth-shaped backwardly directed spines (fig. 6). Similar spines in *Lyctus cavicolis* Leconte (BOSTRYCHIDAE or LYCTIDAE) have been interpreted as cerci by Böving (1923) and others, and it is *prima facie* not easy to decide whether these spines are morphologically cerci or egg-bursters, especially as cases are likely to occur—and have in fact been proved to occur in some TENEBRIONIDAE—where larvae without cerci in later stages show these structures in the first instar. (The fact that physiologically cerci might act as egg-bursters can be neglected here, as the present discussion does not concern the physiological significance of the egg-bursters but only the phylogenetic one.) The presence of egg-bursters on the posterior abdominal segments in Heteromera suggests that in the Terebrantia this condition may have reached

Explanation of Figures.

All figures have been drawn with a camera lucida and a monocular microscope, W designating a Winkel and L a Leitz microscope. The first number after the microscope refers to the eye-piece, the second to the objective used, the following letter to the scale drawn to the same enlargement (e.g. W 1, 3, a means Winkel microscope eye-piece 1, objective 3, scale a). A dotted line indicates a part seen by transparency.

Abbreviations: I, II, III prothorax, mesothorax and metathorax respectively. 1, 2, etc. first, second, etc. abdominal segment. e egg-burster. s spiracle. All figures are of first-stage larvae.

FIG. 1.—*Tenebrio molitor* L. W 1, 3, a. a right egg-burster of the eighth abdominal segment. W 5, 6, b.

FIG. 2.—*Carcinops quatuordecimstriata* Steph. First two abdominal segments. W 4, 3, c. a left egg-burster. W 5, 6, b.

FIG. 3.—*Meligethes* "umbrosus Sturm". Part of prothorax, meso- and metathorax and first abdominal segment. W 2, 6, d. a left egg-burster of metathorax of *M. memnonius* Er., profile seen from the right side. W 5, 6, b.

FIG. 4.—*Pyrochroa serraticornis* Scop. L 1, 3, e (after van Emden, modified). a left egg-burster of prothorax. W 5, 6, b.

FIG. 5.—*Osphya bipunctata* F. Prothorax and mesothorax. W 2, 6, d.

FIG. 6.—*Niptus hololeucus* Fald. Eighth and ninth abdominal segments. W 5, 3, f. a left egg-burster. W 5, 6, b.

FIG. 7.—*Adoxus obscurus* L. Thorax and first abdominal segment. W 5, 3, f. a left egg-burster of metathorax. W 5, 6, b.

FIG. 8.—*Cryptocephalus moraei* L. Thorax and first abdominal segment. W 5, 3, f. a left egg-burster of metathorax. W 5, 6, b.

FIG. 9.—*Calomycterus* sp. Seventh to ninth abdominal segments. W 5, 3, f. a median apex of eighth abdominal segment with egg-bursters (?). W 5, 6, b.

FIG. 10.—*Attelabus nitens* Scop. Fourth to sixth abdominal segments. W 4, 3, c. a part of spiracle and egg-burster in a somewhat more lateral view. W 5, 6, b.

FIG. 11.—*Deporaus betulae* L. First three abdominal segments. W 4, 3, c. a egg-burster and spiracle of third abdominal segment in dorso-lateral view. W 5, 6, b. b the same in dorsal view. W, 5, 6, b.

its extreme by the localisation of the single remaining pair of egg-bursters on the ninth abdominal segment. As fig. 6 shows, the spines in *Niptus* are furnished with a single seta inserted at their base, a very general feature of thoraco-abdominal egg-bursters. The spines are, furthermore, solidly chitinised, *i.e.* they are purely integumental structures, into which the body-tissues do not extend, exactly as is the case in other egg-bursters and in opposition to the condition in cerci. In 1924 I described the unusual fact that the *Niptus* larva hatches from the egg with the hind end breaking the egg-shell and appearing first. This observation strongly supports the interpretation of these spines as egg-bursters. Lastly the position of the organs in question in *Niptus* is basad of the middle of the dorsal surface whilst the normal position of cerci is at or near the hind end of that segment. In *Lyctus* the conditions are apparently the same in every detail, and the spines of the first-stage larva of that genus should therefore probably also be regarded as egg-bursters and not as cerci. It must be mentioned that in the first-stage larva of *Scobicia* Lescne (BOSTRYCHIDAE) the ninth abdominal segment ends in an unpaired truncate median spine, of which no trace is present in later instars (Böving 1923). The present interpretation of the spines of *Niptus* raises the question whether this unpaired organ should also be regarded as an egg-burster, in the same way as the paired frontal egg-bursters of the CARABIDAE are in *Pheropsophus* Solier reduced to an unpaired median spine.

I have not been able to discover egg-bursters in *Micromalthus debilis* Leconte, *Blitophaga opaca* L., *Dermestes* sp., *Byrrhus* sp., *Anthrenus vorax* Wat.¹, *Cantharis fusca* L., *Lampyrus noctiluca* L. (apart from the median tooth of the nasale which, according to Verhoeff, acts as an egg-burster), *Macrelmis consors* Hinton¹, many MELOIDAE, *Lagria hirta* L. and very many adelognathous CURCULIONIDAE, except *Calomycterus* Roelofs. On the other hand, egg-bursters which have already been discovered on the 4th to 6th abdominal segments of *Calandra oryzae* by Hôzawa are present in the larvae of such primitive weevils as *Deporaus betulae* L. (fig. 11, one pair each on the first to seventh abdominal segments) and *Attelabus nitens* Scopoli (fig. 10, one pair each on the fifth and sixth abdominal segments). In *Calomycterus* sp. a pale spine is present on either side of median line at the hind margin of the eighth abdominal segment (fig. 9). Older larvae of *C. setarius* Roelofs do not show a trace of these spines, which may therefore be expected to be egg-bursters.

In CHRYSOMELIDAE egg-bursters are known in CRIOCERINAE and CHRYSOMELINAE. In HALTICINAE Blunck (1932) has mentioned as doubtful egg-bursters a pair of small tubercles on the frons of *Crepidodera ferruginea* Scopoli, but has figured and described the real egg-bursters on meso- and metanotum without recognising them. I have examined first-stage larvae of *Donacia semicuprea* Panzer (DONACIINAE), *Cryptocephalus moraei* L. (CLYTRINAE), *Agelastica alni* L., *Galeruca melanocephala* Ponza, *Lochmaea capreae* L. (GALERUCINAE), *Mantura rustica* L. (HALTICINAE), *Adoxus obscurus* L. (EUMOLPINAE), and some more CHRYSOMELINAE, viz. *Entomoscelis adonidis* Pallas, *Melasoma populi* L. and *Phytodecta olivacea* Forster, and have found egg-bursters in *Cryptocephalus*, *Adoxus* and the three CHRYSOMELINAE. In *Cryptocephalus* (fig. 8) they occur on the meso- and metanotum and consist of a small paired convex sclerite with a small backwardly directed triangular spine, followed by a long seta, whilst in the three CHRYSOMELINAE they are distributed over mesonotum, metanotum and first abdominal tergite, as in other genera of this subfamily, and are of a similar shape as in these. *Adoxus* (fig. 7) has the

¹ Presumable 1st-stage larvae picked out of Dr. H. E. Hinton's material.

egg-bursters arranged as in CHRYSOMELINAE but formed as in *Cryptocephalus*, TENEBRIONIDAE, etc., i.e. a short triangular tooth-like spine in front of a long seta, with the only difference that the spine points outwards instead of backwards.

It will be noted that the egg-bursters so far discussed in Polyphagous Coleoptera are all situated on the dorsum of the thorax and abdomen mediad of the spiracles, and this will become even more obvious when the list given below is consulted. It must, however, be stated that there is one important exception, in which polyphagous Coleoptera are furnished with frontal egg-bursters, viz. some genera of HYDROPHILIDAE. Mr. J. Balfour-Browne, who has been kind enough to let me study his slides of first-stage larvae, will describe these egg-bursters, first discovered by him in *Ochthebius* Thomson, in a forthcoming paper. It will be sufficient here to state that I have not found thoraco-abdominal egg-bursters in any of the specimens, that the egg-bursters of *Anacaena* Thomson are indistinguishable from those of many Dytiscids, and that in *Tropisternus* Solier a similar spiniform tubercle is present on the frontal margin of each parietale opposite the posterior part of the frontale.

In 1925 I reviewed the types of egg-bursters in Arthropoda, and it is desirable briefly to show to what extent the picture then obtained has been changed in the intervening twenty years. Only literature additional to that cited in 1925 will be mentioned, and it will not be necessary to refer again to the egg-bursters occurring outside the class Insecta. Nor will the special egg-bursters of the SILPHIDAE, MACHILIDAE and LAMPYRIDAE be discussed, as they represent isolated types which must be considered caenogenetic, whilst what follows will show that there is strong evidence of the other types having a certain phylogenetic significance.

Acral (frontal) egg-bursters, confined to the embryonic stage and shed with the embryonal cuticle immediately or almost immediately after the rupture of the chorion, have been found in the following groups :—

Dermaptera.

Orthoptera (GRYLLOTALPIDAE, LOCUSTIDAE (Vosseler 1908), PHANEROPTERIDAE).

Mantodea.

Odonata.

Copeognatha (Voss 1921, Weber 1931a).

Mallophaga (Huie 1916, Voss 1921, Wigglesworth 1932).

Anoplura : *Polyplax*, *Pediculus*, *Pedicinus*, *Phthirus*, *Haematopinus* (Sikes & Wigglesworth 1931).

Rhynchota : Heteroptera : PYRRHOCORIDAE (Lengerken 1926), REDUVIIDAE (Sikes & Wigglesworth 1931), CIMICIDAE (*C. lectularius* Sikes & Wigglesworth 1931), COPTOSOMIDAE, PENTATOMIDAE (Boselli 1932a, b), COREIDAE (Heymons 1926, Lengerken 1926, Boselli 1932b). Homoptera : PSYLLIDAE (Speyer 1929), ALEUROIDAE (Weber 1931b), CHERMESIDAE (Voss 1921) [Heymons 1926], APHIDAE (Voss 1921, Gimingham 1925, Heymons 1926).

Megaloptera : SIALIDAE (Smith 1922).

Neuroptera : OSMYLIDAE (Withycombe 1923), SISYRIDAE (Withycombe 1923), CONIPTERYGIDAE (Withycombe 1923), HEMEROBIIDAE (Smith 1922, Withycombe 1923, Killington 1946), CHRYSOPIDAE (Smith 1922, Withycombe 1923).

Trichoptera (Siltala 1907, Ulmer 1925).

In higher holometabolous insects and the LEPISMATIDAE similar egg-bursters are known, but the skin carrying these structures is retained during the

first larval stage, which therefore corresponds to the short phase between the opening of the egg-shell and the moult following upon it in the groups named above. These *persistent acral (frontal) egg-bursters* are known in :—

Thysanura : LEPISMATIDAE.

Diptera Nematocera : MYCETOPHILIDAE, CULICIDAE,² CHIRONOMIDAE, SIMULIIDAE (Puri 1925). In TIPULIDAE (*Tipula* sp.) and ANISOPODIDAE (*Anisopus fenestralis* Scopoli) I have not been able to see egg-bursters.

Aphaniptera (Harms 1912, Oudemans 1913, Sikes 1930, Sikes & Wigglesworth 1931).

Coleoptera Adephaga : CICINDELIDAE, CARABIDAE (Lengerken 1926, Boldori 1933, 1934, 1936, 1939a, 1939b, Scatizzi Branchini 1938, Emden 1942), DYTISCIDAE (all groups including NOTERINAE but except LACCOPHILINAE; Bertrand 1928), HYGROBIIDAE (Bertrand 1928).

The third type of egg-bursters are the *persistent thoraco-abdominal egg-bursters* of the Coleoptera Polyphaga. In 1925 these were known to me only in SCARABAEIDAE, COCCINELLIDAE and CHRYSOMELIDAE. Up till the present time they have been found in the following groups :—

Staphylinoidea : STAPHYLINIDAE : *Platystethus* (Hinton 1944) on metanotum.

Hydrophiloidea : HISTERIDAE : *Carcinops* (present paper) on the dorsum of the first abdominal segment.

Lamellicornia : LUCANIDAE (Emden 1941) on meso- and metanotum; PASSALIDAE (Heymons 1929) on metanotum; SCARABAEIDAE (Madle 1934, Emden 1941, Böving 1942); on meso- and metanotum in GEOTRUPINAE and APHODIINAE, on metanotum in Pleurosticti.

Clavicornia : COCCINELLIDAE (Strouhal 1927), NITIDULIDAE (present paper).

Heteromera : TENEBRIONIDAE (Kolobova 1927, not recognised; present paper), PYROCHROIDAE (present paper), MELANDRYIDAE (present paper).

Teredilia : LYCTIDAE (Böving 1923, interpreted as cerci), PTINIDAE (present paper).

Phytophaga : CERAMBYCIDAE : *Aromia* (present paper), CHRYSOMELIDAE : CRIOCERINAE, CLYTRINAE (present paper), EUMOLPINAE (present paper), CHRYSOMELINAE (Weise 1902, not recognised; Bruneteau 1924); HALTICINAE (Blunck 1932 "on frontale" but unrecognised on meso- and metanotum); BRUCHIDAE (Kunhi Kannan 1923, not recognised, a spine above first abdominal spiracle).

Rhynchophora : CURCULIONIDAE : *Calandra* (Hôzawa 1929), *Deporaus*, *Attelabus*, ? *Calomycterus* (present paper).

As I pointed out in 1925, genera or groups without an egg-burster are often closely related to genera in which this structure is well developed. The very wide distribution of the frontal egg-bursters, especially in families which are otherwise characterised by numerous primitive characters, renders it certain that the frontal egg-bursters are a paligenetic character of the insects. There is also little doubt that the persistent frontal egg-bursters have evolved from the purely embryonic ones and that both are homologous. This again shows that the embryonal cuticle shed immediately after the opening of the chorion or the penetration of tertiary egg-covers in hemimetabolous insects and Neuroptera etc. must be homologous with the first larval skin of the higher holometabolous insects. These views, already propounded in my 1925 paper, are being strongly corroborated by the evidence which has since come to light, although Heymons

² The egg-bursters of CULICIDAE larvae have been figured and described in numerous papers not listed here.

(1926) came to precisely the opposite opinion, *i.e.* that the aeral egg-bursters have evolved independently in the groups of insects where they are found.

On the other hand, the thoraco-abdominal egg-bursters were in 1925 listed for only three unconnected families of the Coleoptera Polyphaga. It has now become obvious that this is the normal and widely distributed type of egg-burster in that suborder. It has been found in at least some representatives of all series of families except Dascilloidea and Malacodermata-Sternoxia (as used in my classification of beetle larvae—Emden 1942—*i.e.* including Dryopoidea + Brachymera and Cleroidea respectively). The wide distribution of thoraco-abdominal egg-bursters in Polyphaga makes it almost impossible to assume an independent origin for them in the various groups, and thus renders it highly probable that these egg-bursters are a palingenetic feature of that suborder of beetles.

Although the Heteromera certainly cannot be considered one of the oldest groups of the Polyphaga, their egg-bursters represent undoubtedly the most primitive type of thoraco-abdominal egg-burster yet known, and the same type must have been present in a more ancient group, from which both Staphylinidea-Hydrophiloidea-Lamellicornia and Clavicornia-Heteromera-Phytophaga-Rhynchophora are derived. At any rate, only the assumption of an original distribution over many segments of the body can explain the occurrence on different segments in more closely related groups, such as the subfamilies of Lamellicornia or CHRYSOMELIDAE.

There is, however, one fact which contradicts this assumption: the occurrence of frontal egg-bursters in some HYDROPHILIDAE. In order to fit this discrepancy into the general scheme one of the following hypotheses must be accepted:—

(1) The HYDROPHILIDAE are the most primitive Polyphaga and approach the Adephaga more closely than any of the other families, or

(2) The frontal egg-bursters of the HYDROPHILIDAE have evolved independently, whilst the thoraco-abdominal egg-bursters of the other Polyphaga are of common origin;

(3) The egg-bursters of Polyphaga have evolved independently everywhere.

There is no doubt that the HYDROPHILIDAE are very primitive Polyphaga in many regards, *e.g.*, the articulating cerci of the larva found in the LIMNOBIINAE etc. (to which one of the genera with egg-bursters belongs), the two maxillary lobes occurring in the *Spercheus* larva, the presence of frontal sutures in the adult, and of ocelli in some adult LIMNOBIINAE (Crowson 1944). On the other hand, the highly specialised breathing arrangements in larvae and adults will hardly allow them to be considered more primitive than the rest of the Polyphaga together. Obviously the group Staphylinidea-Hydrophiloidea-Lamellicornia is connected with the Clavicornia-Heteromera-Teredilia-Phytophaga-Rhynchophora by the Dascilloidea, and the lack of knowledge of the egg-bursters of this group affects the ability to judge the frontal egg-bursters occurring in some HYDROPHILIDAE. However, the presence of thoraco-abdominal egg-bursters both in Staphylinidea-Hydrophiloidea-Lamellicornia and in Clavicornia-Heteromera etc. seems to leave little room for the presence of palingenetic frontal egg-bursters in any group belonging to these series or intermediate between them. On the other hand, the HYDROPHILIDAE cannot very well claim a primitive position based on the division of the phylogenetic tree into the three rows Staphylinidea-Hydrophiloidea [HISTERIDAE]-Lamellicornia, Dascilloidea-Malacodermata-Sternoxia and Clavicornia-Heteromera-Teredilia-Phytophaga-Rhynchophora. This would make the second alternative of an inde-

pendent, caenogenetic evolution of the frontal egg-bursters in the HYDROPHILIDAE more probable than the first, and the pair of tubercles on the inner margin of the parietalia in *Tropisternus* Solier might be considered to support the second hypothesis. At any rate, there is little in support of the third possibility, except perhaps the fact that many genera and probably a considerable number of families in Polyphaga are without any egg-bursters. The same applies, however, to the frontal egg-bursters of other insects, and there is thus little doubt that thoraco-abdominal egg-bursters are a primitive character of the suborder Polyphaga.

My thanks are due to Mr. E. A. J. Duffy for first-stage larvae of *Pyrochroa coccinea*, *Abdera flexuosa* and *Osphya bipunctata*, to Dr. A. M. Easton for those of *Meligethes memnonius* and *umbrosus*, to Dr. H. E. Hinton for first-stage larvae of *Pyrochroa serraticornis*, *Macrelmis consors*, and *Anthrenus vorax*, to Mr. S. A. Jacobs for living adults of *Carcinops quatuordecimstriata* and to Mr. J. Hobart and the London School of Hygiene and Tropical Medicine for living adults of *Tenebrio molitor*. Madame Baribalov of the staff of the Imperial Institute of Entomology has been kind enough to translate for me large parts of Kolobova's paper.

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ON THE PIGMENTATION OF THE BODY LOUSE *PEDICULUS HUMANUS* L.

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Nymphs and adults of the human body louse show considerable variability in their degree of pigmentation. This variability is illustrated in fig. 1, which shows the range in pigmentation from colourless specimens to those with very dark brown or black sclerites and a greyish darkening of the softer parts of the cuticle. The amount of body colour has sometimes been used as a secondary diagnostic character to distinguish subspecies (*e.g.* a dark variety on negroes) or quoted as a difference between the head and body races. It seems, however, that no reliance can be placed on this as a taxonomic character.

In 1917, Hindle made some preliminary breeding experiments from which he concluded that the degree of pigmentation was inherited; and he claimed to have isolated a colourless strain. At this point his work was interrupted by military service in the first World War, and was apparently never described in detail.

Two years later Nuttall (1919) published a paper which appeared to discredit Hindle's observations, for he found that the colour of the background during nymphal development had a profound effect on the colour of adult lice. Individuals which had been reared on a white background were pale, while those from a black background were pigmented. The colour could be modified during the forty-eight hours preceding the final moult but, when the adult stage was reached, it was invariable. Nuttall came to the conclusion that Hindle must have been misled and quotes the case as a warning to investigators engaged in the study of heredity.

It seemed surprising that two careful workers should have reached opposing conclusions and therefore corroborative experiments were undertaken. The investigation was conducted in four stages to answer the following questions:—

1. Is the pigmentation of lice dependent on the background during development?
2. If so, is this acquired character inherited?
3. Is it possible to isolate dark and light strains reared on the same background?
4. If so, what is the result of crossing such strains?

Technique.—The lice used were taken from a stock of body lice reared in the laboratory for at least five years by the methods described by Buxton (1939). They were kept in gauze-bottomed pill-boxes worn against the skin of the leg allowing them to feed at will during 12–15 hours a day. Under such conditions they flourish and, after the first feed, there is usually only a negligible mortality.

The degree of coloration was estimated visually in the living specimens, which were classified according to their resemblance to the four arbitrary types shown in fig. 1, namely: DD (very dark); D (dark); L (light); LL (unpigmented).

The results can be conveniently summarised in diagrams (figs. 2, 3 and 4) showing the proportions of the four gradations of pigmentation in various families.

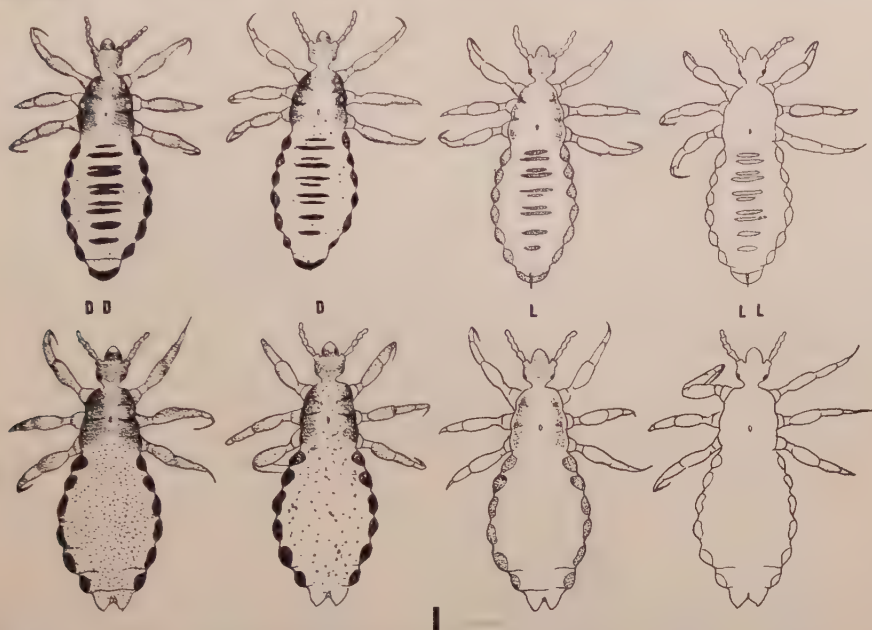
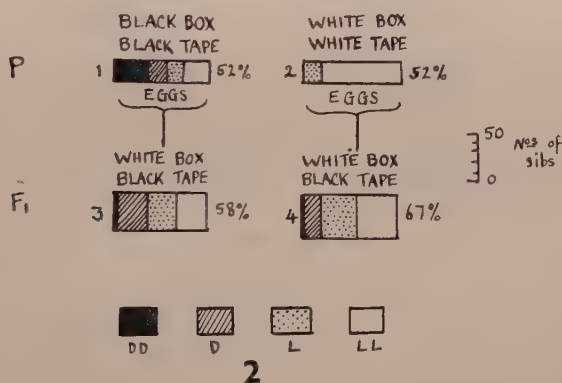


FIG. 1.—The four degrees of pigmentation referred to in the text. Above male lice, below female lice. (Drawn from life.)



2

FIG. 2.—Diagram illustrating Experiments 1 and 2. Each block represents a family. The depth is proportionate to the number of sibs and the proportions of different grades of pigmentation are indicated horizontally by shading. Figures on the left of each block give the number of the family. The percentage on the right of the block gives the proportion of females.

Experiment 1.—The nymphs hatched from a batch of eggs were divided into two groups and one group reared in a black-lined pill box on black tape while the other group was kept in a white box on white tape. From the black diagrams in fig. 2 it will be seen that there were considerably more pigmented

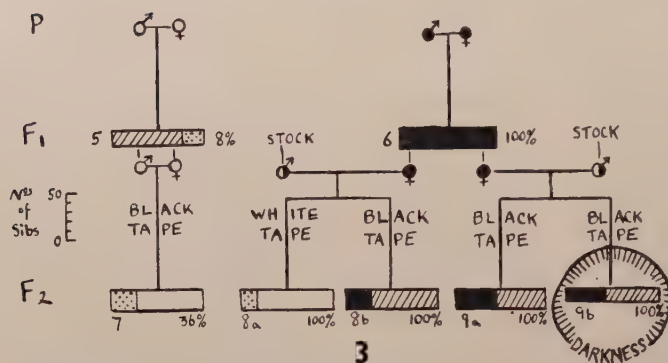


FIG. 3.—Diagram illustrating Experiment 3. (Symbols as in fig. 2.)

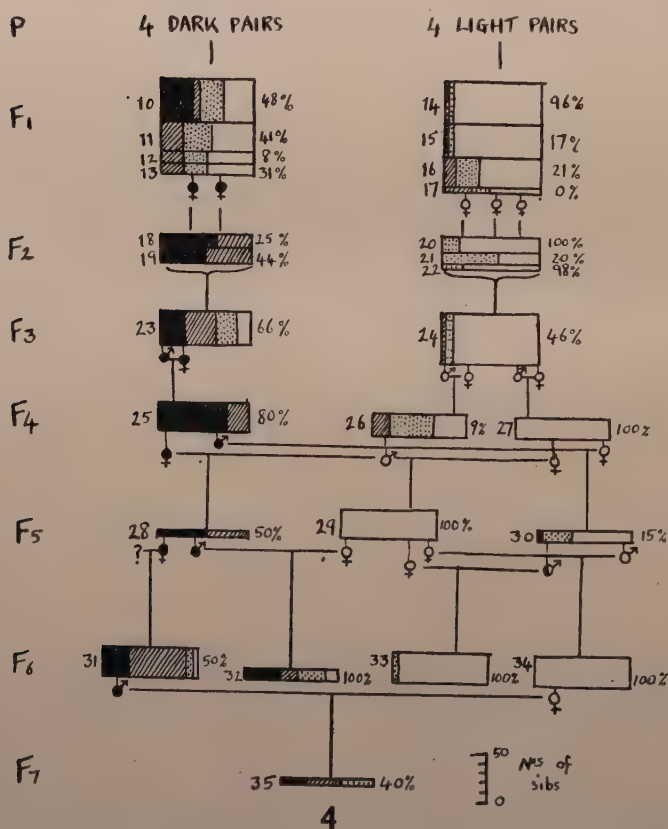


FIG. 4.—Diagram illustrating Experiment 4. (Symbols as in fig. 2.)

adults in the black box than in the white box as would be expected from Nuttall's experiments. Nevertheless, it is noteworthy that there is a substantial proportion of pale lice in the dark box and a small number of dark lice in the white box.

Experiment 2.—Eggs laid by the two groups of lice described above were incubated and the progenies reared separately, but under identical conditions, namely on black tape in white boxes. On their becoming adult they were examined and categorised, the proportions of dark and light individuals being shown in fig. 2 (families 3 and 4). Both groups showed about the same proportions of dark lice; there was no indication of an inherited tendency to darken.

Experiment 3.—A dark and a light virgin female isolated from the breeding stock were mated respectively with a dark and a light male. Their offspring were reared separately but under identical conditions on black tape in white boxes. When they had become adult it was found that the proportions of dark lice was much higher among the progeny of the dark pair. (See fig. 3, F1.) From the pale family (5) a light pair was mated and their offspring reared normally on black tape. The dark family (6) was unfortunately entirely composed of females. Two of them were mated with moderate coloured males from the general stock and the egg batches from both matings were each divided into two and treated as follows :—

{ Group 8a : Reared normally on white tape.
 { „ 8b : Reared normally on black tape.
 { „ 9a : Reared normally on black tape.
 { „ 9b : Reared in complete darkness. (Under a black bandage while feeding and in a light-tight tin when off the leg. Checked by inclusion of photographic paper which was subsequently developed.)

The resulting adult colorations of these groups are illustrated in fig. 3 (F2 generation). Two conclusions can be drawn from them :—

(i) Since the “dark” group (8a) which was reared on white tape was as pale as the pale-selected family (9) on black tape, it appears that it is the ability to darken which is inherited and not a residual dark colour.

(ii) Dark coloration can be developed in complete darkness. Since this is contrary to Nuttall's results, the experiment was repeated; 1st stage nymphs taken from the breeding stock were reared in tins under different conditions with the following results :—

Rearing conditions	Coloration of adults
White tape : exposure to light	0% D and DD
Black tape : exposure to light	42% „
White tape : complete darkness	53% „

Experiment 4.—Throughout this experiment all families were reared under similar conditions : namely black tape in white boxes.

The attempt was made to isolate two strains; one incapable of reacting to background and one reacting strongly, and then to try cross matings.

Isolation of strains.—Four light and four dark pairs from the general stock were mated and their progenies, reared separately, are shown as the F1 generation in fig. 4. They show some evidence of inheritance of pigmentation already.

Unfortunately it was not possible to obtain known matings in this generation, but two very dark and three very light females were selected and their

progenies reared separately to become the F2 generation. The effect of selection was now more marked. The eggs laid by the dark families were united and the general egg stock of the light families was similarly combined. These two groups became the families shown as F3 in the diagram. From them a very dark pair and two very pale pairs were isolated as virgins and mated to produce the F4 families.

At this point the selection for light and dark strains ceased. Marked differences in the proportions of the four colour groups had been obtained by selective breeding of lice reared under the same conditions.

Cross matings.—Cross matings were now carried out with individuals in various families in generations F4, F5 and F6.

The experiment was complicated and handicapped by the frequent occurrence of unisexual families, especially all-female families,¹ which were also frequently encountered in experiment 3. On account of this difficulty, only a limited number of the desired matings were possible: their results did not yield very definite conclusions, but can be summarised as follows:—

Families (30), (32) and (35) are all the progenies of very dark males and very pale females; they are all intermediate in grading. Family (28) was the only one from a dark female mating with a light male, and a rather high nymphal mortality renders the results unreliable.

In general, one might conclude that there is no evidence of a simple or sex-linked inheritance. Probably more than one gene is involved and the selection was not continued long enough to isolate pure strains.

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 HINDLE, E., 1917, Notes on the biology of *Pediculus humanus* L. *Parasitology* 9 : 259–65.
 NUTTALL, G. H. F., 1919, The biology of *Pediculus humanus* L. (Supplementary notes). *Parasitology* 11 : 201–20.

¹ It is, perhaps, worth noting that two females of the all-female family 6, and three females of the all-female family 29, gave all-female progeny, though mated with different males. In Hindle's (1917) data, there is a record of one family (No. 4 of "second generation") of 13 males and 15 females. Five of the latter were mated with males from other families and gave two all-female and three all-male families.

There seems to be a tendency for the females of certain families to produce unisexual progenies.

APPENDIX : CONSTITUTION OF THE VARIOUS FAMILIES.

M = Males; F = Females.

DD, D, L and LL indicate coloration as shown in fig. 1.

Family No.	DD		D		L		LL	
	M	F	M	F	M	F	M	F
1	3	3	3	3	1	3	5	4
2	0	0	0	0	2	2	10	11
3	0	1	3	4	5	10	8	7
4	1	1	5	10	7	7	3	13
5	0	0	10	0	2	1	0	0
6	0	19	0	0	0	0	0	0
7	0	0	0	0	4	2	10	6
8a	0	0	0	0	0	4	0	19
8b	0	5	0	13	0	0	0	0
9a	0	5	0	6	0	0	0	0
9b	0	7	0	12	0	0	0	0
10	3	11	2	2	9	3	7	9
11	0	0	6	1	7	2	6	10
12	0	0	3	0	3	0	6	1
13	0	0	3	0	0	3	6	1
14	0	0	0	3	0	2	2	38
15	0	0	2	0	2	0	25	6
16	0	1	4	0	6	0	14	8
17	0	0	2	0	1	0	3	0
18	7	2	2	1	0	0	0	0
19	4	5	5	2	0	0	0	0
20	0	0	0	0	0	3	0	16
21	0	0	0	0	5	1	3	1
22	0	0	0	0	2	0	3	2
23	1	11	6	6	3	5	3	4
24	0	0	2	1	1	4	19	23
25	4	21	2	3	0	0	0	0
26	0	0	6	0	10	0	5	2
27	0	0	0	0	0	0	0	19
28	1	2	2	1	0	0	0	0
29	0	0	0	0	0	0	0	29
30	0	0	2	0	3	0	6	2
31	4	5	8	10	2	0	1	0
32	0	4	0	2	0	3	0	1
33	0	0	0	0	0	3	0	33
34	0	0	0	0	0	0	0	28
35	0	1	1	1	2	0	0	0

BOOK NOTICES.

Insect Dietary, an Account of the Food Habits of Insects. By CHARLES T. BRUES. 8vo. Cambridge, Mass. (Harvard Univ. Press), 1946. Pp. xxvi + 466, 22 plates, 68 text-figures. Price \$5.

This book comprises an interesting and attractively written survey of the diverse relations of insects to their environment through the medium of their food, and of the way in which their activities have affected many other forms of animal life, and plant life. The work is divided under three main headings, the first dealing with the abundance and diversity of insects, types of food habits and their relation to structure and environment. Under the second heading, "Vegetarianism," an account of herbivorous and gall producing insects is given; of species feeding upon fungi, bacteria and yeasts, and examples of symbiosis with micro-organisms. In the third division, under the heading "Carnivorism," are included chapters dealing with predatory insects, parasitism, external and internal insect parasites, and a final chapter devoted to insects as food for man and other organisms. A valuable feature, and one which should make this book a useful work of reference, is the ample bibliography placed at the end of each chapter. The numerous half-tone plates have been reproduced from a very fine series of photographs.

Honey Bees and their Management. By STANLEY B. WHITEHEAD. 8vo. London (Faber and Faber, Ltd.), 1946. Pp. 153, 48 Plates, 16 text-figures. Price 12s. 6d.

The text of this volume is arranged in two parts. The first provides a straightforward and practical guide to successful bee-keeping, and includes the life-history and annual cycle of the honey-bee, their appropriate management, selection of hives and general equipment. In the second part the more technical aspects of bee-keeping are treated; this includes a description of the anatomy of the bee, nutritional value of honey, and a study of the more advanced methods of swarm control and queen-rearing. A very valuable and fully tabulated list of British wild and cultivated bee-plants, giving the common and specific name of each plant, flowering season, type of pollen, and honey rating is included. The author also gives a timely word of warning concerning the dangers to bee life arising from the careless use of poisonous sprays and other forms of insecticides, particularly the danger of D.D.T., which appears to act as a slow nerve poison, killing either by contact or after ingestion. This synthesized chemical (Dichloro-diphenyl-trichloro-ethane) is effective in very low concentrations, and whether applied in powder or spray form, remains lethal for some length of time after application. A short bibliography is divided under three headings, namely, "Practical," "Scientific," and "Descriptive."

Insects of the British Isles. By N. Barrie HODGSON. 8vo. Bognor, Sussex. (John Crowther Ltd.) Pp. 82, 20 coloured Plates. Price 7s. 6d.

The complete avoidance of all technical terms should help the beginner, and make this book an easy guide to the more familiar British species. The general characters of the larva, pupa, and imago are briefly described, together with

notes on the food-plants, habitat, and the season of the year when the imago may be expected to appear.

Queen rearing. By L. E. Snelgrove. Pp. x + 344, 35 plates. 8vo. Bleadon, Somerset (I. Snelgrove). 1946.

This book should prove a very welcome addition to the existing literature on British bee keeping, since no English book specifically devoted to the subject has appeared since the second edition (1913) of Sladen's *Queen rearing in England*. The book is divided into two parts, the first dealing with what may be termed the scientific background of the subject, *i.e.* general anatomy of the queen and the drone, life-history, types of brood food, heredity. The second part is devoted to the practical side of scientific queen-rearing in all its details. The book as a whole forms a comprehensive work of reference to a fascinating and all-important branch of modern bee keeping, and includes a useful bibliography.

Although scientific queen-rearing in this country is chiefly practised by a limited number of professional bee-breeders who regularly supply the market, there is no serious obstacle in the way of the small-scale bee keeper improving his stock by such means, provided that he is prepared to take sufficient care in selection from his available hives and pay attention to the details of manipulation as set forth in Mr. Snelgrove's book.

Gall midges of economic importance. Vol. I, *Root and Vegetable Crops*; Vol. II, *Fodder Crops*. By H. F. BARNES. 8vo. London (Crosby Lockwood & Son, Ltd.), 1946. Pp. 104, 10 pls., and pp. 160, 3 pls. Price Vol. I, 12s. 6d.; Vol. II, 15s.

These are the first contributions towards a work to be completed in eight volumes, of which two more will appear in the autumn of 1946, and the remaining volumes V to VIII in 1947. To quote from the Foreword to Vol. I: "Dr. Barnes has set himself the task of writing a comprehensive account of all those species of Gall Midges, throughout the world, that are of economic interest either as pests of crops or as beneficial insects." Such a comprehensive work of reference has been a long-felt want, and should prove of great assistance both to those engaged in economic research and the field entomologist interested in the bionomics of these insects. The literature relating to the Gall Midges is fairly extensive and widely scattered in journals and monographs often difficult of access, so that the very comprehensive bibliography attached to each volume should prove of great value. The illustrations are admirable.

Bibliographia Araneorum. Analyse méthodique de toute la littérature aranéologique jusqu'au 1939. Tome 1. By P. BONNET. 8vo. Toulouse (the Author, University of Toulouse), 1945. Price 3,000 frs. Pp. xviii + 832, 28 pls.

This volume, one of the three projected for the complete work, contains the introduction, the alphabetical list of authors and their writings and a bibliographic index arranged by subjects. Vol. 2 is to give a classification of spiders, a list of common names and a bibliographic index systematically arranged. Vol. 3 is to contain the alphabetical list of all the names cited in Vol. 2. The 28 half-tone plates included in Vol. 1 form an interesting collection of portraits of well-known araneologists.

The Fauna and Flora of the Ilfracombe District of North Devon. Edited by Mervyn G. Palmer. With a Foreword by F. S. Wallis. 8vo. Exeter (James Townsend & Sons, Ltd.), 1946. Pp. vi + 266, 8 plates and Map. Price 7s. 6d.

This latest addition to the literature dealing with the Fauna and Flora of North Devon is the work of some of the members of the Ilfracombe Field Club, and may be regarded as a noteworthy achievement, and an example which many local natural history societies might well follow. Each Division is headed by a short comprehensive introduction, and brief notes of type of locality or other useful information appear against many of the recorded species. The section devoted to Entomology includes records of Odonata, Lepidoptera, Coleoptera and Diptera; and the number of species included amply demonstrates the energy and enthusiasm of the recorders.

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MEETINGS

TO BE HELD IN THE SOCIETY'S ROOMS

41, Queen's Gate, S.W.7

1947.

WEDNESDAY, January 15 (ANNUAL MEETING)

„ February 5

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

The Fellowship and Fees

Fellows pay an Admission Fee of £3 3s. The Annual Contribution of £2 2s. is due on the first day of January in each year, and is payable in advance. Fellows under the age of 25 years may pay the entrance fee in three equal annual instalments.

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Forms of application for Fellowship, copies of the Bye-Laws and the List of Fellows may be obtained from the Hon. Secretary.

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